HEATING AND VENTILATING EAST LANSING SCHOOL

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THESIS

This thesis was contributed by

Mr. G. L. Lardie

under the date indicated by the department stamp, to replace the original which was destroyed in the fire of March 5, 1916.

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THESIS

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THE BUILDING AT PRESENT The school building is a brick structure of two stories and basement, the three floor plans of which accompany this work. The building consists of two parts, the original building and the addition placed in front of the former and now comprising the main part. The walls of the new part contain a two and one-half inch air space. The building is equipped thruout with double windows, except the east side of the assembly room on the second floor and the two front rooms on the first floor. Heating is accomplished by steam supplied from a 23" Ideal boiler of eight sections (American Radiator Company), with a rating of 2375 sq. ft.. This supplies 1755 sq. ft. of radiation distributed as shown upon floor plans. The regulation is entirely by hand. In the new portion, two banks of flues run up from the basement to the roof, one in the east part and the other in the west part of the wall separating the corridor from the school rooms. In several instances, where the foul air stack is in the same tier as the fresh air stack of the room below, these stacks are not properly separated, which condition it will be necessary to remedy. In each bank there is one flue which is unused. In the old building, the old chimney furnishes vent flues for the first floor and the west second floor rooms, while there is one unused flue opening into the basement.

INTRODUCTION TO THE PROBLEM. This thesis was undertaken as a result of dissatisfaction and trouble which have arisen with respect to the results obtained during the past winter from the present heating system. On several occasions during the cold weather, the entire school had to be dismissed because of insufficient heat. At times the building could not be thoroughly warmed until after school had convened, even tho the janitor would start the fire as early as 4:30 A. M. In all due fairness, it may be said that some of the school authorities hold the opinion that even in the coldest weather, if the furnace is properly fired, there will be no difficulty in heating the building. This is borne out by the fact, which afterward developed, that during the previous winter, which was much colder, little trouble was experienced.

At present, the only ventilation is by means of windows, and by ventilating flues leading from the rooms of the new building to the roof. In the old building, the wall back of each radiator has been cut thru and a galvanized iron slide placed over this so that fresh air can enter the room from the outside, coming thru the radiator and being warmed.

Tests were made of the condition of the air in the school with respect to both the amount of CO_2 contained and the humidity. The CO_2 test was made by means of an apparatus using phenolphthalin as an indicator. Two cubic centimeters of the liquid containing this were placed in a graduated glass cylinder fitted with a piston, thru the center of which, as it was drawn out, air was admitted to the center of the cylinder.

When, after thoroughly shaking, it was found that just sufficient air had been admitted to make the indicator colorless, the bleaching being due to the action of the contained CO_2, this amount was taken as an inverse measure of the gas, the actual percentage of CO_2 then being obtained from a curve. The humidity tests were made by means of a wet and dry bulb thermometer.

The results of these tests follow.

<u>Percentage of CO_2 in Air</u>

February 27	February 28
Assembly room on second floor	
3:15 P. M. .038% CO_2 4:00 " .063 " Ventilators in storm windows were open until 3:20, then they were closed. Temperature, 73° F.	10:40 A. M. .045% CO_2
South-West Room, second Floor	
3:45 P. M. .103% CO_2 Temperature, 74°	11:20 A. M. .078% CO_2 Vents open back of radiators. Temperature, 66°
South-East Room, Second Floor	
	11:30 A. M. .072% CO_2 Vents open back of radiators. Temp., 66°
North-West Room, First Floor	
3:25 P. M. .07% CO_2 One window open 4" Temp., 71°	10:35 A. M. .078% CO_2 All windows open thru recess at 10:30. Temp., 72°
North-East Room, First Floor	
3:20 P. M. .05% CO_2 One window open 2". Temp., 64°	10:40 A. M. .08% CO_2 One window open thru recess at 10:30. Temp., 67°
Back Room, First Floor	
3:30 P. M. .175% CO_2 Radiator ventilators on one side of room partly open. Temp., 67°	11:45 A. M. .072% CO_2 Radiator ventilators partly open on both sides of room. Temp., 75°

As long as the CO_2 does not exceed .07%, conditions are not bad. It is thus seen that in these cases the air is fairly good

HUMIDITY TESTS

Room			Relative Humidity Time....2/26 3:30 P.M.	2/29 11:00 A.M.	1/23 4:30 . .
Assembly room,	2 nd.	floor	51.9 %	56.3 %	39.0 %
N. W. Room,	"	"	47.3	37.0	32.0
S. W. room,	"	"	50.3	30.3	37.0
Physics lab.	"	"	47.3	....	40.5
N. W. room,	1 st.	"	49.5	41.3	34.0
N. E. room,	"	"	50.0	45.5	38.9
South room,	"	"	53.5	31.7	40.0

The relative humidity should not run below 40 %, so it is seen that in one or two cases, it is a bit low.

THE [illegible] VENTILATING of a room should accomplish certain results.

(1) A correct and even temperature thruout all parts of the room under various weather conditions.

(2) A thorough diffusion of fresh air thruout the level or zone of breathing.

(3) A prompt removal of foul air.

(4) A means of avoiding perceptable drafts of either warm or cold air.

It is toward the attainment of the above standards that we shall direct our efforts in this thesis.

THE [illegible] The first work consisted in checking the radiation already installed. This was done with the aid of Harrison's Chart, which for a given set of temperatures and given conditions of wall, window or air change, gives

the area of wall or window, or cubic contents of room supplied by one square foot of steam radiation. An inside temperature of 70° in the rooms and 50° in the halls, and an outside temperature of 0° were assumed. The radiator temperature was taken as 220°. The window and wall areas and cubic contents were taken from the plans obtained from the architect. The sum of the amounts of radiation required for each of the three items, window area, wall area and cubic contents, corrected by the proper exposure factor, gave the amount of radiation required for the entire room. In the new building, the wall area supplied by one square foot of radiation was increased 15% on account of the air space, for which Harrison does not allow. Snow gives authority for this in "The Principles of Heating", page 43. The data giving the amount of radiation required as above and already installed radiation, is given in Table I (Blue-print). It will be noted that with the exception of the back room down stairs, which has too much, there is at present insufficient radiation. In the basement clay rooms, where pipe coils are used, the radiation already installed is assumed to be correct as the results obtained from it are entirely satisfactory and basement radiation is uncertain to compute.

The total amount of direct radiation required is 2179 sq. ft. and the indirect, 330 sq. ft. as will be shown later. This makes a sum total of 2509 sq. ft. to be supplied by the boiler. According to the best practice to obtain the proper sized boiler, the amount of radiation should be increased by 50%.

1.5 x 2509 = 3770 sq. ft. rating of boiler.

The American Radiator Co. furnishes a 36" boiler of eight sections and 3 - 5" outlets, which will fit this case. This boiler will require a 15" smoke pipe.

With the present system of piping, the radiators in the new building have a three-inch and two two-inch returns, while the old building has a three-inch supply and one two-inch return. The new building requires 1592.1 sq. ft. of direct radiation and the old, 486.9 sq. ft. Hoffman's Handbook of H. and V., Table 27, page 302 gives the capacity of a 3" supply and 2 1/2" return as 15[illegible] sq. ft. with 5# gage pressure. The amount required is so little over this that the present piping is considered adequate.

THE VENTILATING SYSTEM. The plenum system was adopted as the most satisfactory method of ventilation. The air supply was figured on the basis of 1300 cubic feet per hour per pupil. The data for this part of the work is given in Table [illegible]. If the air is admitted at a temperature sufficiently reduced to compensate for the heat given off by the bodies of the pupils, figured at 300 B.T.U. for each one, the temperature of the air entering the rooms will be 58° as shown by the following figures:

$$\frac{1}{55} = \text{specific heat of air (B.T.U. per cu.ft.)}$$

$$\frac{300 \times 55}{1300} = 12^{\circ} \text{ drop.}$$

$$70^{\circ} - 12^{\circ} = 58^{\circ} \text{ Temp. of entering air.}$$

If the air is admitted at this low temperature , there will undoubtedly be undesireable drafts and it is therefor advisable to have a higher temperature of 65°. A temperature lower than that of the room is also desireable because such air is more bracing and this cooler fresh air will fall into the breathing zone after leaving the radiators.

With the air entering at this temperature, it is either necessary to reduce the direct radiation or provide automatic thermostatic control. The first should not be done because in that event, the building might not be heated to the required temperature unless the pupils were in the rooms, supplying heat, a condition which is not always present. With the plan of thermostatic control, there will be sufficient radiation at all times to heat the rooms under all conditions but never excessively, as the automatic control will close the valves at the desired maximum temperature.

It was decided to place the fan and heater for the plenum system in the east play room, near the ceiling so as to obtain a gravity return to boiler and to draw the air thru a cellar window facing north. The small store-room under the front stairs was selected for the plenum chamber, the arrangement of this and the ducts leading from it being shown on the basement floor plan. On account of the ease of installation and compactness, a Vento heater was selected to warm the air.

The calculations for this heater are as follows:

References are to "The Engineers' Data Book on Vento Heaters". Published by the American Radiator Co. in 1912.

Temperature of air entering.................0°

" " " leaving.................65° F.

Maximum steam pressure.....................5 lbs.

Amount of air heated.......................560,[illegible] cu.ft./hour.

Specific heat of air entering at average temperature

of 32.5°..................................$\frac{1}{55}$ B/t.u./cu.ft.

$\frac{540,000 \times 65}{52}$ = 670,000 b.t.u. required per hour of heater.

(P.17) Allowable velocity thru heater of four sections = 1,000 to 1,500 ft. per minute.

(P.21) Velocity of 1,400 ft. per minute will give a final temperature of 65^o

(P.21) For a regular section with 5 3/8" centers of loops, three stacks deep, we find that the condensation per square foot per hour, is 2.25 lb.

Latent heat of steam at 5# pressure is 960

2.25 x 960 = 2160 b.t.u. per square foot per hour from heater.

$\frac{670,000}{2,160}$ = 310 square feet of heating surface required.

310 divided by 3 = 103.3 square feet per section.

$\frac{540,000}{60 \times 1400}$ = 6.4 sq.ft. free area thru heater required.

(P.12) A regular 40" section with 6.57 sq.ft. free area and [illegible] sq.ft. of heating surface per section is the nearest approach to the size required.

We may find a nearer approach to the size of heater required by using one four sections deep. Try a narrow section with [illegible] spacing.

(P.27) To give a temperature of 65^o a velocity of 1200 ft. per minute is required.

Condensation = 2.11 lbs. per sq.ft. per hour.

2.11 x 960 = 2025 b.t.u. per sq.ft. per hour.

$\frac{670,000}{2,025}$ = 330.5 sq.ft. of heating surface required.

330.5 divided by 4 = 82.6 sq.ft. of heating surface per section.

$$\frac{540,000}{60 \times 1,200} = 7.5 \text{ sq. ft. free area thru heater.}$$

(P.13) Using 7 loops per stack, a narrow 60" section with 5 3/8" spacing, having a free area of 7.35 sq.ft. and 77 sq.ft. of heating surface per stack, gives the size nearest that required.

This last is selected because a greater flexibility in the control of the air temperature may be obtained. This is accomplished by providing valves to cut the steam off from each of the four sections, according to the temperature of the air entering the heater.

The dimensions of this heater are:

Height..................61"

Width...................41"

Depth...................30"

(P.14) A 2 1/2" supply pipe and a 1 1/2" return will be required and should be run directly from the furnace, as the steam main in the new building is not of sufficient capacity to take care of this also.

THE FAN CALCULATIONS are as follows:- The fan should deliver 9[illegible] cu.ft. of air per minute at a pressure of 3/8 oz. for this class of work. Specifications are given for two fans which will satisfy the requirements.

The Green Fuel Economizer Co. build a fan running at 224 r.p.m. delivering 8,909 cu.ft. of air per minute at 3/8 oz. pressure, and requiring 1.707 h.p.

The Buffalo Forge Co. build a fan, Conoidal Fan No.70, running at 272 r.p.m., delivering 8,450 cu.ft.per minute at 1/2 oz. pressure and requiring 2.14 h.p.

The most satisfactory service will be obtained by using a motor of suitable horse power, belted to the fan selected as a direct connected slow speed motor is too expensive.

<u>The Ducts, Stacks, Registers, etc</u> Three main ducts will be used to distribute the air from the plenum chamber to the stacks, one leading to the east bank of flues and one to the west bank and one leading to a bank of flues to be installed in the old building between the physics laboratory and the recitation rooms, running up the wall inside the latter, from the basement. The sizes of these ducts are calculated on the basis of an air velocity of 1000 ft. per minute. The two in the new building will be the same.

Air supplied by each = 183,000 cu.ft.per hour.

$$\frac{183,000}{60 \times 1000} = 3 \text{ sq.ft. area of duct (East and West).}$$

South Duct.

Air supplied = 176,400 cu.ft.per hour.

$$\frac{176,400}{60 \times 1000} = 2.95 \text{ sq.ft. area of duct.}$$

The same dimensions will be used for all three, 22 1/2" x 18". The arrangement of ducts is shown upon the floor plans.

The stacks already installed in the new addition will be used to lead the fresh air from the main ducts into the rooms and to

furnish outlets for foul air. In the old part it will be necessary to in stall flues to lead from the ducts to the rooms, as mentioned on the previous page. However, but one vent stack will need be built, this being for the south-east second floor room. The chimney flues will be used to ventilate the other two rooms in the old building. The stacks leading to the second floor rooms in front are of such a size that with the proper amount of air, a velocity of 525 ft. per minute is obtained. This velocity is taken as a standard for the other stacks.

The fresh air registers were calculated for a velocity of 420 ft.per minute, taken as sufficient to send the air across the rooms without causing perceptible drafts. It will be allowable to use a free opening out of the stacks for the air inlet into the rooms, as the exit is so high that there is no danger of refuse getting into the stack from that source. In all the rooms except the south-east and south-west ones on the second floor, diffusers should be used over the outlets to properly direct and distribute the out-coming air. This unnecessary in the two mentioned rooms because these are long and narrow, the air going nearly straight across. The inlet registers which are now in the new building, will give too high a velocity and should be replaced by diffusers with the proper opening. The diffusers should be constructed of galvanized iron, according to the drawings which accompany.

The vent registers may be given the same sise openings as the inlets. A screen however should be placed in the opening of each as it is at the floor line. In the new building, since a somewhat higher velocity will do no harm, the present vent registers may be used. In the old building, the first floor room will use the opening already cut in the chimney and one to be cut into the unused flue, for foul air outlets. The south-west room on the second floor has a register at the floor line leading into a third chimney flue, which will be used as an outlet. A foul air stack leading to the [illegible] will have to be installed in the south-east room, having an opening at the floor line.

The stacks which it will be necessary to install in the old building are shown on the floor plans and will be constructed of galvanized iron. The following table, taken from "Elements of Heating and Ventilating" by Green, shows the proper gauge of metal to use to give the required stiffness.

Gauge (U.S. Metal Gauge)	Thickness in inches	Duct sizes (Limiting square)
26	3/160	6" x 6"
24	1/40	12" x 12"
22	1/32	20" x 20"
20	3/80	21" x 21" and up.

The arrangement of stacks and registers is shown on floor plans and the data for the several rooms is given in Table II.

<u>VENTILATION OF TOILETS.</u> A separate exhaust fan should be used for the ventilation of the toilets. It should be placed in the attic so that a discharge thru the roof and above the ground may be obtained. The unused flue in each [illegible] may be used to carry the foul air away from the toilet in which

it starts, the two stacks being connected to the fan in the attic.

<u>Calculations of fan for toilet</u>

Air needed to ventilate toilet = 2,400 cu.ft. per hour per fixture.

From Allen's Notes on H. & V., p.146.

In each toilet there are six fixtures.

$$\frac{2,800 \times 12}{60} = 560 \text{ cu.ft. per minute, required of fan.}$$

A buffalo Electric "B" Volume Exhauster, No.4 running at 855 r.p.m., requiring .15 h.p. and supplying 575 cu.ft. per minute, will fill the requirements.

<u>TEMPERATURE CONTROL</u> As before mentioned, the building should be equipped with a system of automatic temperature control, a thermostat being placed in each class room to operate the radiator valves therein.

The specifications and estimate of the expense of the change in the present system of heating and ventilating of the East Lansing School, as recommended by this thesis, are given on the following pages.

[illegible]

Radiators

Peerless type, manufactured by the American Radiator Co.

First Floor

[illegible] Room 14 sections - 3 col.- 26"...............14.00

[illegible] " 12 " " " 12.00

Back Hall 16 " 2 col. " 11.50

Front " 3 -22 " 3 " " 67.00

3 - 1 1/2" valves....................... 11.25

Second Floor

Assembly Room 26 sections - 3 col.- 26"............... 26.50

Corridor 2 -19 " 2 col. " 27.25

2 - 1 1/4" valves....................... 6.00

Labor.......................145.00

Pipe and fittings.......... 23.00

total............348.50

Indirect Heater

Vento Cast Iron Sections, manufactured by American Radiator Co.

Narrow - 60" - 4 sections - 5 3/8" spacing............84.00

5 - 2 1/2" valves.................................... 25.00

1 - 1 1/2" " 3.25

Pipe....36 ft. 2" steel............................. 4.50

36 " 1 1/2" steel.......................... 3.25

Fittings.. 2.00

Labor and sheet-metal casing........................ 24.00

total........ 146.00

FANS

Main Fan.

One fan capable of handling 2,000 cu.ft. of air per minute at 3/8 oz. pressure, (installed).......................... $240.00

Suction fan for toilets.

One fan capable of handling 500 cu.ft. of air per minute at 3/4 oz. pressure, (installed).......................... 25.00

total....... $265.00

Motors

Fort Wayne, A.C. Induction Motors, voltage = 110

H.P.	Speed	Price, including control.
1/4	1800	$45.00
2 1/4	1800	150.00
	Installation of both.......	25.00
	total.....	$220.00

Boiler

The present boiler will not be large enough to supply the radiators and indirect heater coils, so the purchase of a new boiler capable of supplying both, is advocated. The following will fulfill the conditions. Manufactured by the American Radiator Company.

Ideal - 3 - 36" - 8.................................. 800.00

This price is for boiler installed.

Air Ducts

Material - U.S. Sheet-metal, galvanized, 2[illegible] gauge.

Weight per square foot.............1 1/2 lbs.

No. of square feet.................757

Weight of main ducts...............1140 lbs.

Cost, in place.....................10 cts.per lb.

Cost of main ducts...................................114.00

Stacks

First Floor

Heat stack, south room.

Use 22 gauge, weight = 1 1/4 lbs.per sq.ft.

Number of sq.ft.= 54, Cost.......................... 6.75

Use chimney for vent stack.

Second floor

Heat stack, south-east room.

Use 22 gauge, No. of sq.ft. = [illegible] Cost............. 12.50

Vent stack

Use 22 gauge, No. of sq.ft. = 66 Cost............. 8.25

South-west room.

Similiar heat stack, use chimney for vent stack..... 12.50

Laboratory.

Heat stack, 24 gauge, 55 sq.ft....................... 5.50

Vent stack, " 37.5 " 3.75

Duct for suction fan

Use 24 gauge, 40 sq.ft............................ 40.00

total......... 203.25

Automatic Control of Direct Radiation

7 thermostats.......at $22.......................... 154.00

21 valves........... " 8.......................... 168.00

total..........$322.00

Summary of Costs.

Radiators.....................$549.50

Indirect Heater.............. 146.00

Fans......................... [illegible]65.00

Motors....................... 5[illegible]0.00

Boiler....................... [illegible]

Ducts........................ 114.00

Stacks....................... 39.25

Automatic Control............ 322.00

Diffusers.................... 2.50

total........ $2367.25

The above prices were obtained from trade catalogues and Mr. [illegible] F. Newell.

[illegible]

of

[illegible]

[illegible]

FURNACE A 36 inch Ideal Boiler, of eight sections, made by the American Radiator Co. should be installed in place of the present boiler. This boiler has a rating of 3675 sq.ft.

A 15" smoke pipe should be installed in place of the present 12" pipe.

DIRECT RADIATION This should be changed in the various rooms according to the figures shown on the floor plans. The following table gives the number of sections to be added or taken away from each radiator. The letters refer to the radiators as lettered on the drawings.

Room	A	B	C	D	E	F	Columns
N.W., 1st. floor	6	4	4				3
N.E. " "	4	4	4				3
South " "	-4	-4	-4	-3			2
Front Hall "	22	22	23				3
Back " "	9	7					2
Assembly, 2nd. floor	3	5	5	5	5	3	3
E.W. " "	-5	-5					2
S.W. " "	-4	-4					2
Phycics Lab. "	2						3
Corridor, " "	0	19	19				

(-) Take sections out.

INDIRECT RADIATION A vento indirect heater should be installed. This should consist of four narrow 60" sections with 5 3/8" spacing, each section to be of seven loops and having a free area of 7.5 sq.ft. and a heating surface of 77 sq.ft.

The heater should be placed as shown on floor plan, as near the ceiling as the construction will allow. A 2 1/2" supply and 1 1/2" return should be used.

THERMOSTATIC CONTROL A system of thermostatic control of the radiator valves should be installed. A thermostat should be placed in every school room, on an inside wall. Each radiator in a room should be connected to a thermostat therin.

VENTILATING SYSTEM FOR SCHOOL ROOMS A fan should be installed to furnish 90[illegible] cu.ft. of air per minute at 3/8 oz. pressure.

The motor to drive the fan should be belted thereto, should have the proper capacity and should run at 1[illegible] r.p.m.

The store-room under the stairs should be made into a plenum chamber and connected with the fan and main ducts as shown on the basement floor plan.

Three main ducts should be installed as shown on the floor plans, leading from the plenum chamber, one to the east, one to the south and one to the west. These should all be made the same size, 1' 3" x 2' 4 1/2" and should be made of galvanized iron, 2[illegible] gauge, U.S. Metal Standard.

Stacks and registers to furnish the ventilation for the rooms in the old building should be installed as follows:

The stacks should run up inside the school room on the south wall, according to the table shown below.

1 stack, 36"x 7 3/4", leading from main duct into 1 st.floor room.
1 " 24"x 7 3/4" " " " " " S.E. room, 2 nd. floor
1 " 24"x 7 3/4" " " " " " S.W. " "
1 " 24"x 7 3/4" " " S.E. room, 2 nd.floor into attic.

These should be made of No.22 galvanized iron.

1 stack, 9 3/4"x 7 3/4", leading into physics lab. from main duct.
1 " " " " from " " into attic.

The air inlets should be placed with the lower side 6 ft. above the floor line. The outlet should be placed at the floor line.

Screens should be placed over the outlets except where the old chimney is used as such. Registers should be used in that case.

An opening to act as outlet should be cut into the unused chimney flue at the floor line in the first floor room. The opening of this flue into the basement should be closed.

All inlets should be screened.

Diffusers should be placed over the inlets of the physics laboratory and the first floor room.

The dimensions and styles of inlets and outlets to be used in the old building are shown in the following table.

<u>Inlets</u>

1 st.floor room..............24" x 16 1/4".....diffuser.
S.E. room, 2nd.floor.........24" x 11".........screen
S.W. " " " ....24" x 11" ....screen
Physics Laboratory...........11" x 9 1/2"......diffuser

Cutlets

1 st.floor room.........1 register installed
12" x 16" register to be installed
[illegible] Room, 2 nd.floor.....24" x 11" screen
[illegible] " " " .....24" x 11"...register installed.
Physics Laboratory.......11" x 9 1/2" screen

The ventilating arrangement in the new building should be changed according to the following.

Proper connection should be made between the main ducts and the stacks as shown on floor plans.

Proper division should be made between the fresh air stacks and foul air stacks, when they occur in the same flue.

The inlet registers should be replaced by diffusers, each having an opening 24" x 22". These diffusers should be made of galvanized iron, gauge No. 2[illegible] as shown by by the sketch accompanying this thesis.

THE VENTILATION OF THE TOILETS The arrangement for the ventilation of the toilets should conform to the following:

An opening at the floor line, to take a 12" x 16" register, should be cut from each toilet into the inside stack of each bank of flues in the new building.

Theses stacks should be connected by galvanized iron ducts to an exhaust fan located in the attic.

An exhaust fan capable of handling 560 cu.ft. of air per minute at 3/8 oz. pressure, should be installed in the attic.

A motor of suitable horse-power to drive the fan, should be belted to the same and should be run at 1[illegible] r.p.m.

TABLE -I-

EAST LANSING SCHOOL

RADIATION COMPUTED FROM HARRISON'S CHART

Room	Actual wall area	Exposure factor	Equivalent wall area	Glass area	Volume	Air changes	Amt. per sq.ft of Radiation: Glass	Amt. per sq.ft of Radiation: Wall	Amt. per sq.ft of Radiation: Air Leakage	15% cor. for Wall Air-Space	Sq.ft of Radiation: Glass	Sq.ft of Radiation: Wall	Sq.ft of Radiation: Air Leakage	Sq.ft of Radiation: Total	Final Sq.ft. of Radiation	Radiation installed
							First Floor									
N.E.	636	20	455.5	240.5 s	9900	2	2.8	9.9	81.5	11.6	87.5	39.2	121.2	247.9	297.5	243.75
N.W.	696	20	455.5	240.5 s	9900	2	2.8	9.9	81.5	11.6	87.5	39.2	121.2	247.9	297.5	251.25
South	483	10	351	132 d	7240	1½	5.8	7.3	109	7.3	22.8	48.1	66.5	137.4	151.2	192.
E. Hall	828	0	796	31. s	13187	3	4.3	15.5	85	18.25	72.6	43.2	155.	270.8	270.8	96.
B. Hall	504	5	585		2840	3		11.5	85	11.5		50.9	33.4	84.3	88.5	45.3
							Second Floor									
Assembly	1800	20	1217	162 s 421. d	28850	1	2.8 5.8	[illegible]	109	11.6	57.8 72.6	104.5	265	499.9	600.0	502.5
E. Back	299	5	230.5	68.5 d	4410	1	5.8	7.3	161	7.3	11.8	32.2	27.4	71.4	75.	106.7
W. Back	299	10	230.5	68.5 d	4410	1	5.8	7.3	161	7.3	11.8	32.2	27.4	71.4	78.6	106.7
Phy. Lab.	504	5	456	32.2 d	2840	1	5.8	7.3	161	7.3	9.0	62.5	17.6	89.1	93.6	86.25
Corridor	700	0	650	168 s	7880	2	4.3	15.5	128	18.25	39.1	35.7	61.5	136.3	136.3	34.66
							Basement									
															45	45.
N.E.															45	45
N.W.																
															2179	1755.15

Single Windows = s
Double " = d
Inside Temp. all class rooms = 70°
" " corridors = 50°

TABLE -II-

EAST LANSING SCHOOL

VENTILATING DATA

Room	Number of occupants	Cu. ft. of Air Required per hour	Duct area Present For Fresh air	Register area-present	Vel. in duct	Vel. thru register	Duct area Required	Req. area required	Vel. in duct	Vel. thru register
					FIRST FLOOR					
N.E.	52	93600	384	384	585	585	384	534	585	420
N.W	50	90000	384	384	585	585	370	515	585	420
South	38	68400					280	390	585	420
					SECOND FLOOR					
Assembly	100	180000	768	768	420	420	2-370	2-515	585	420
S.E.	25	45000					185	257	585	420
S.W.	25	45000					185	257	585	420
Phy. Lab.	10	18000					74	103	585	420
	Total..	540000	per hr.							
		9000	" min.							
					BASEMENT					
Girls Toilet		16800	Ventilated by Separate Suction-Fan							
Boys Toilet		16800								

AIR DIFFUSER

For

Physics Laboratory

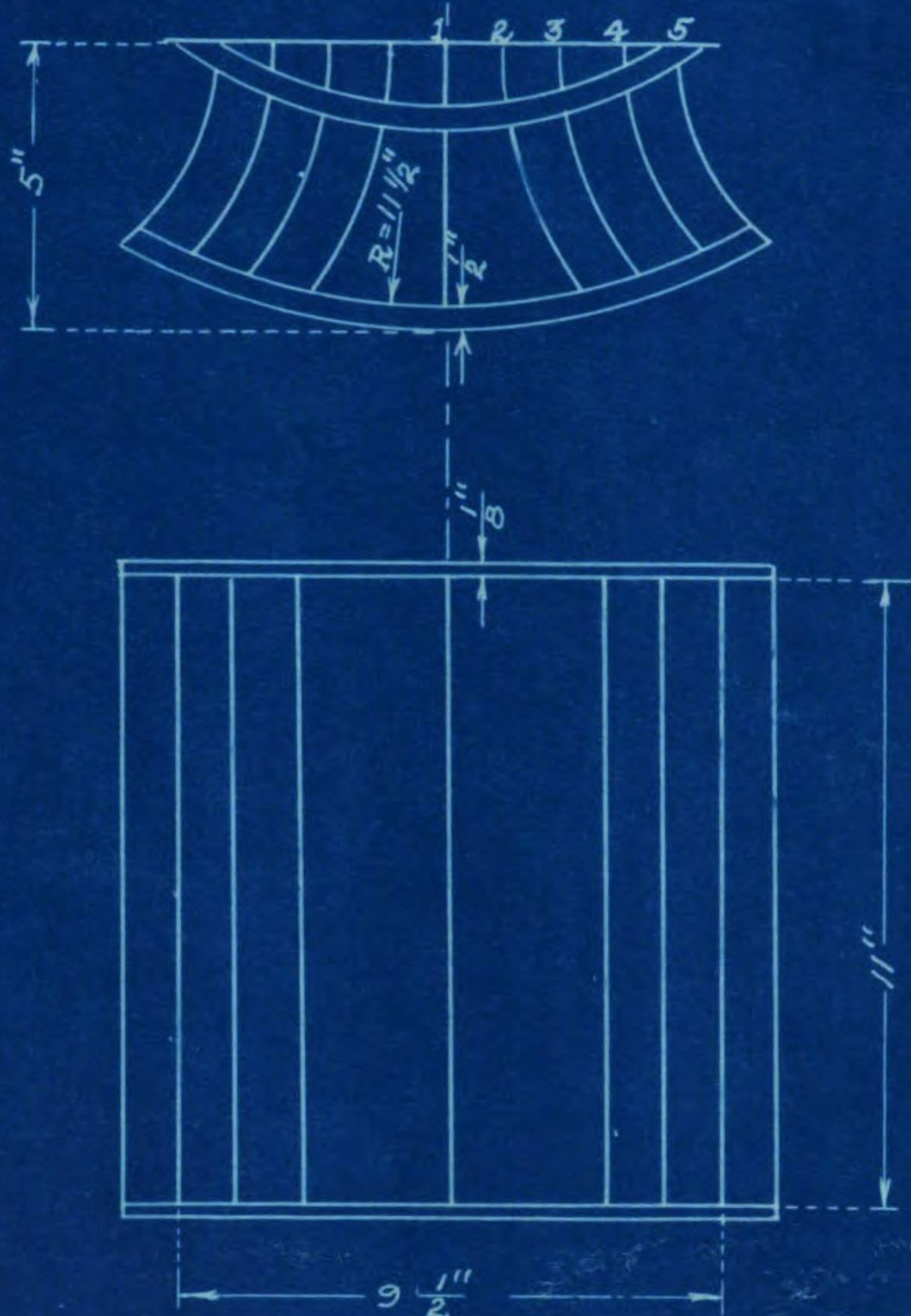
$R_2 = 7\ 1/2''$

$R_3 = 6\ 1/2''$

$R_4 = 5\ 1/2''$

$R_5 = 4\ 1/2''$

1" spacing of bafflers.



Scale, 1/4" = 1"

AIR DIFFUSER

For

South room, 1 st. Floor.

R_1 = Straight

R_2 = 12"

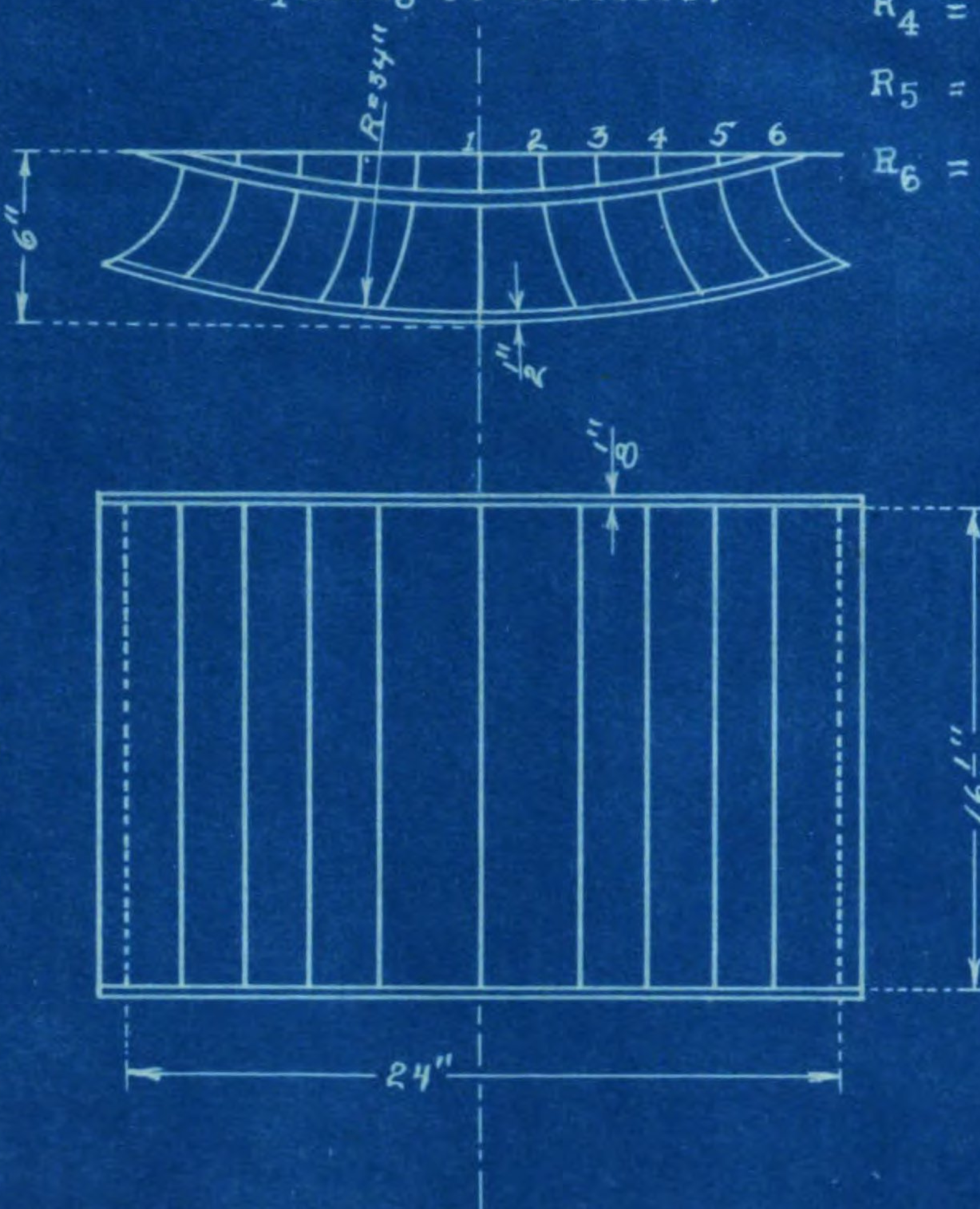
R_3 = 10"

R_4 = 8"

R_5 = 6"

R_6 = 4"

2" spacing of bafflers.



Scale, 1/8" = 1"

<u>AIR DIFFUSER</u>

For

South room, 1 st. Floor.

R_1 = Straight

R_2 = 12"

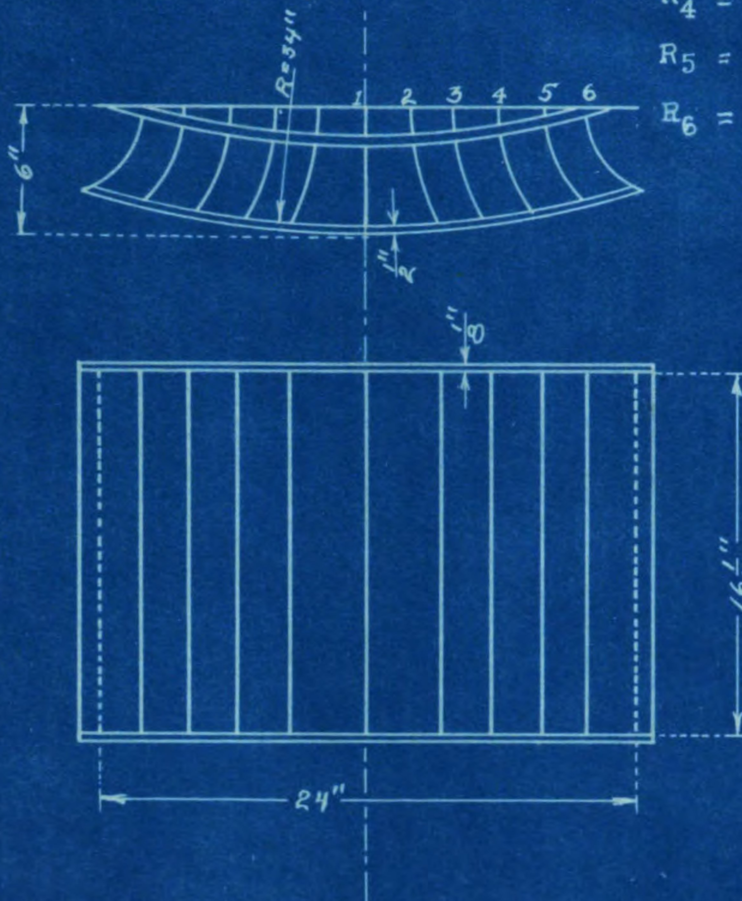
R_3 = 10"

R_4 = 8"

R_5 = 6"

R_6 = 4"

2" spacing of bafflers.



Scale, 1/8" = 1"

AIR DIFFUSER

For

Assembly Room

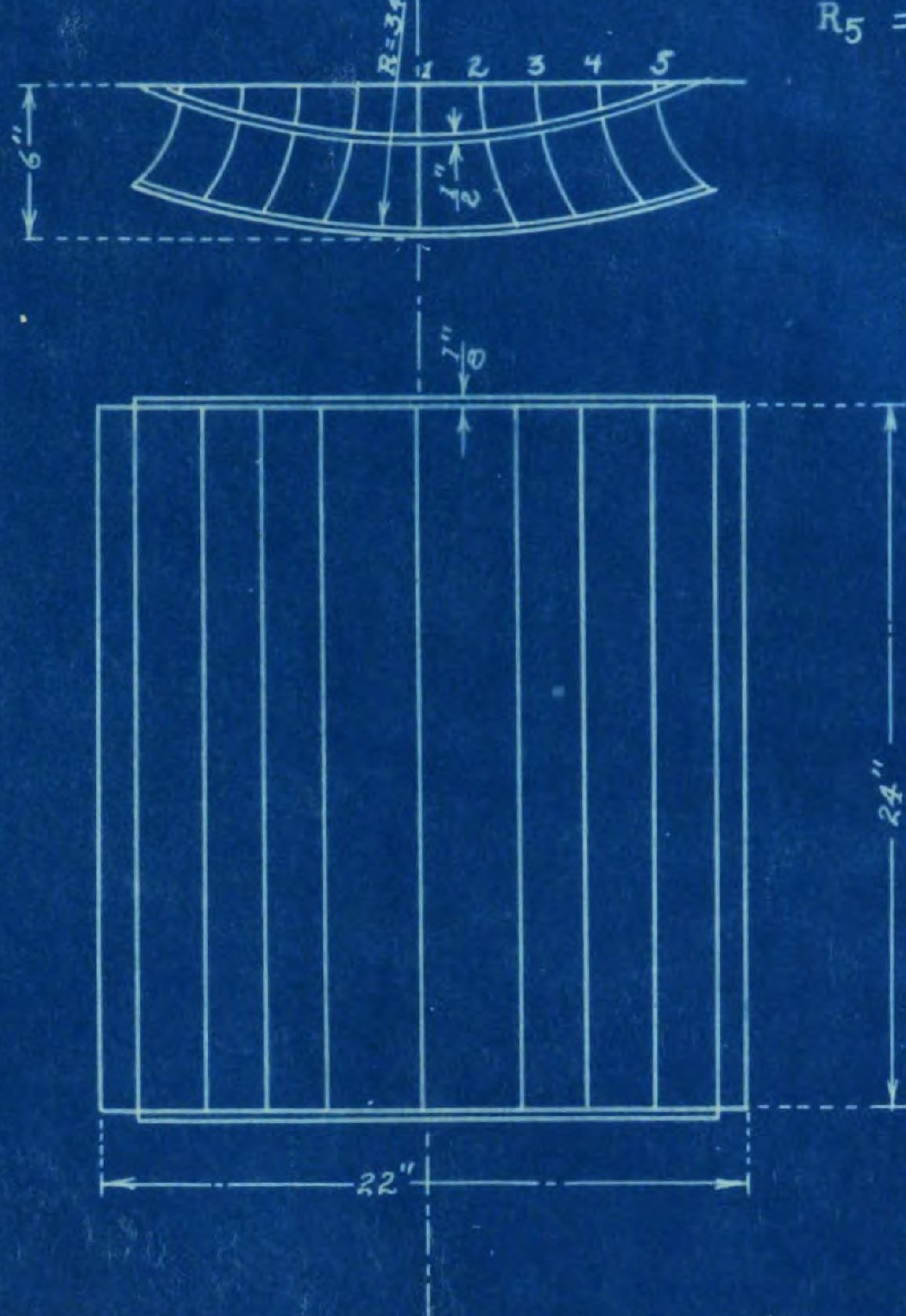
R_2 = 10 1/2"

R_3 = 8 1/2"

R_4 = 6 1/2"

R_5 = 4 1/2"

2" spacing of bafflers



Scale, 1/8" = 1"

AIR DIFFUSER

For

Assembly Room

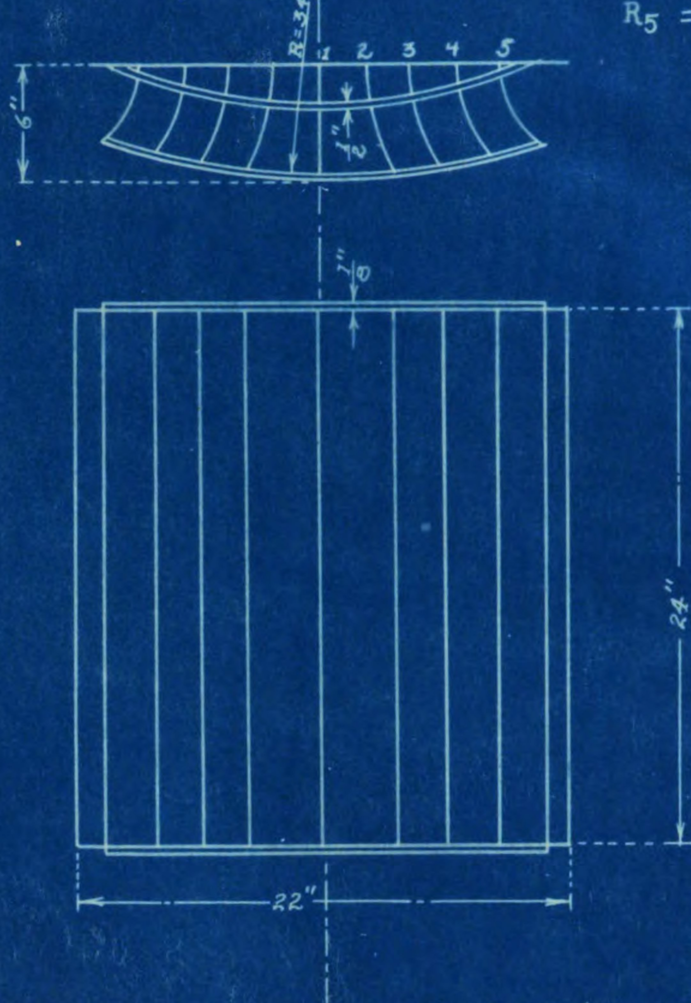
$R_2 = 10\ 1/2''$

$R_3 = 8\ 1/2''$

$R_4 = 6\ 1/2''$

$R_5 = 4\ 1/2''$

2" spacing of bafflers



Scale, 1/8" = 1"

SUPPLEMENTARY
MATERIAL

FIRST FLOOR

Pocket has 3 Suppls

SUPPLEMENTARY
MATERIAL

FIRST FLOOR